SMDs? Don't panic!

Surface mount techniques at your workbench

By C. Tomanik

Surface Mount Technology (SMT) is responsible for today's ever smaller electronic equipment. Many new IC's are now only available in SMD outline. These tiny components can pose a few problems for the electronics enthusiast, not the least being the cost of special SMT tools. If SMDs make you nervous, don't panic, this introduction will give tips on SMD working methods and help you decide what you really need and what you can do without in the Lilliput land of the SMD.

These days some electronic components are supplied only in SMD package outlines. This can often leave the electronic hobbyist in a bit of a dilemma: should you use SMD components only where there is no alternative and conventional wire-ended components elsewhere in your latest design or should you plump for SMD throughout?

In this series of articles we hope to show that switching completely to SMD is often the most sensible solution and need not incur a great deal of expenditure in tools and specialist work stations.

Working with SMDs can be easier than you think provided that you are armed with one or two of the more essential tools. It is not necessary to buy expensive solder re-work stations, a standard 30 to 60 W soldering iron is up to the job providing it is fitted with a suitably fine bit.

This article is the result of experience gained while working with SMDs during the author's graduation studies.

The basics

As the name suggests, an SMD (Surface Mounted Device) is mounted on the surface of a Printed Circuit Board (PCB). It is not necessary to put a hole in the PCB to take the component leads. Contacts on the component are soldered to 'pads' or 'lands'

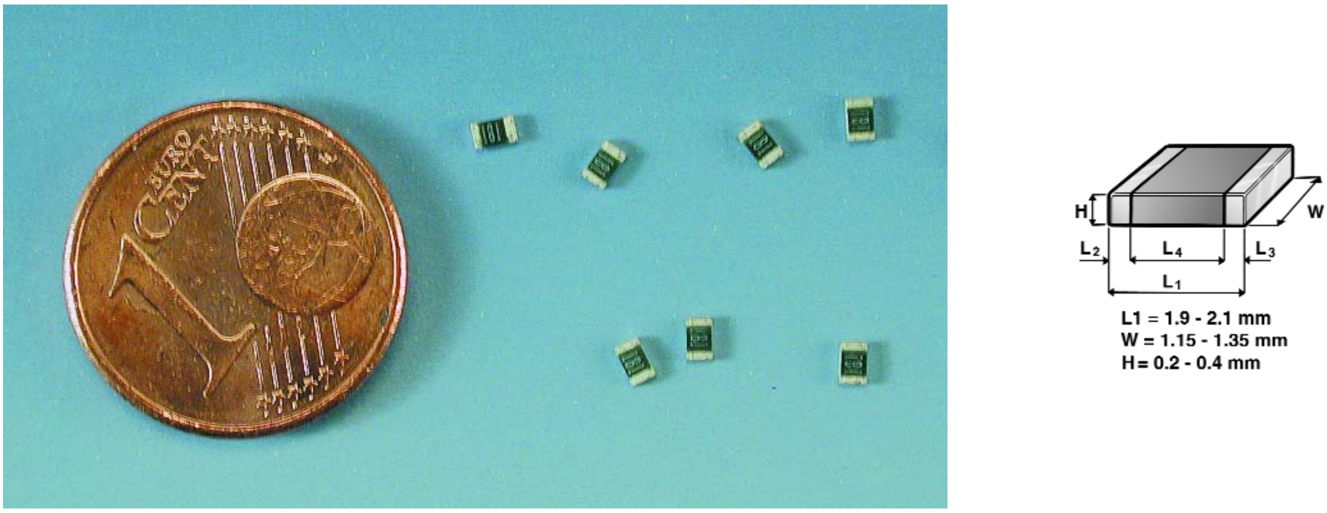

Figure 1. Scale diagrams of the 1206, 0805 and 0603 outlines and illustration of an 0805 size resistor.

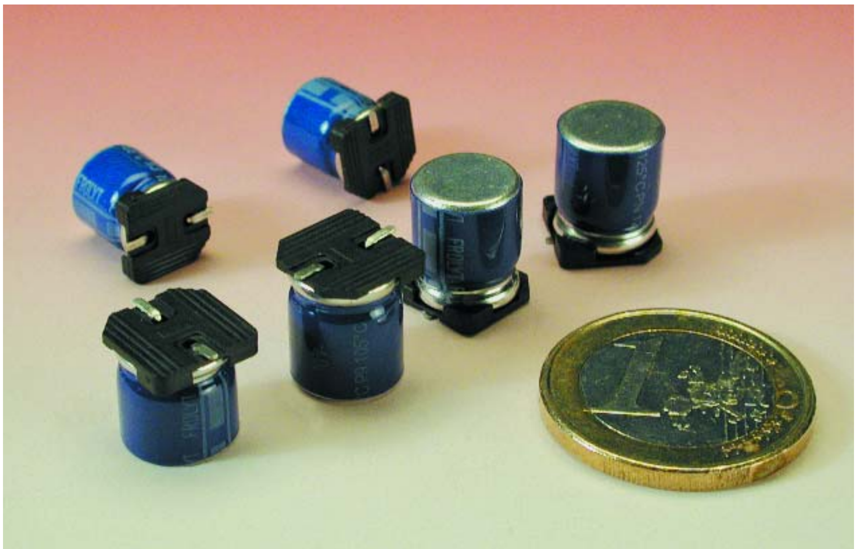

Figure 2. Electrolytic capacitors.

at the ends of PCB tracks. Without leads the SMD components are much smaller and take up less space on the PCB, resulting in a more compact design. The shorter leads also improve the components RF characteristics and when fitted the component will always be at the same height above the PCB. This is important at high frequencies and makes the overall design more reproducible.

To sum up, SMDs offer cheaper, smaller designs but they do require more careful PCB layout (running tracks under components can be very tricky) and fitting components to a PCB is more difficult for the beginner.

SMD packages

Each type of electronic component is produced in its own range of SMD packages and can be grouped under the following headings:

- Chip resistors/capacitors (0805)
- Chip electrolytics
- Tantalum capacitors (3516)
- Diodes (Mini-MELF)
- Transistors (SOT 23)
- Integrated Circuits (ICs)

There are so many package outlines (especially for ICs) that it would be impractical to go into details for each individual outline. The aim of this article is to provide a basic introduction to the techniques necessary for working with SMD components. It is always advisable to study package outline information on the data sheet for any IC that you intend to use. Make sure that it is possible to solder the devices by hand because some IC's outlines are specifically designed to be fitted by special placement machines and may be too tricky.

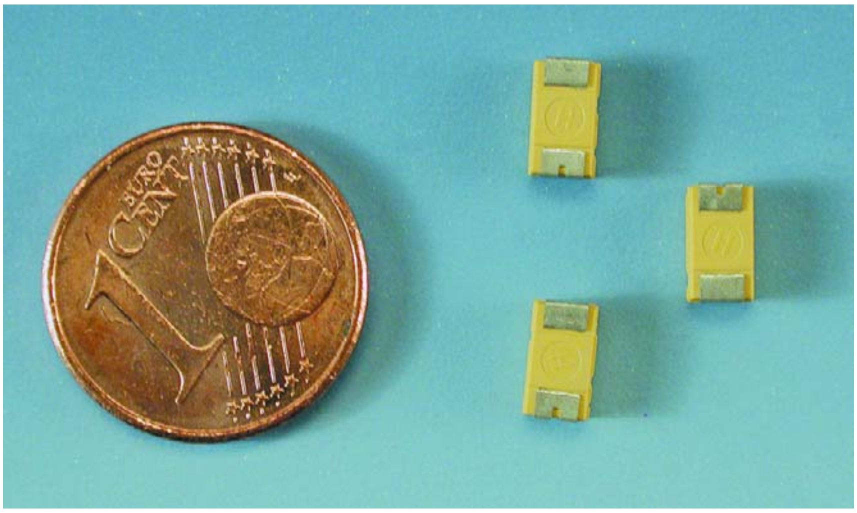

Figure 3. The 3216 tantalum capacitor outline.

Chip resistors and capacitors

The most common devices used in a design are resistors and ceramic capacitors. They are available in a rectangular 'chip' outline with a conductive cap at either end to solder to the PCB pads. The chip size is given by the description 1206, 0805, 0603, 0402 or 0201 the first two numbers give the chip length while the last two give the width. The measurements are Imperial so that 0805 means that the chip is 0.08" by 0.05". To convert to metric multiply these values by 25.4, this gives a chip size of 2.032 mm by 1.27 mm. **Figure 1** shows the outlines for 1206, 0805 and 0603 chips. These packages are relatively easy to handle and solder, a standard iron will be sufficient to mount these devices.

Electrolytic capacitors

SMD electrolytic capacitors use conventional electrolytic outlines with radial leads fitted into a plastic housing that guides the leads out of the bottom of the package enabling it to be surface mounted (**Figure 2**). The capacitor rating determines the outline size. A capacitor with a 4 mm diameter body for example, will take up a board area of 4.3 mm by 4.3 mm and have a height of 5.5 mm. These outlines do not have any special names.

Tantalum capacitors

Tantalum capacitors outlines can be described using two different systems. The EIA code for a particular size is a four-digit number giving the package size, similar to the way that resistor dimensions are specified. The difference with tantalums is that the dimensions are metric! An outline specified as 3216 will be 3.2 mm long by 1.6 mm wide. The other method of describing the size is to specify its single letter 'case code'. The 3216 package has the case code 'A'. Many data sheets give the EIA codes and their case code equivalent. EIA codes with an 'L' suffix indicate that the capacitor is low-profile and its height will not exceed 1.2 mm. Outlines without the 'L' could be as high as 2.9 mm.

Diodes

Most general-purpose diodes are produced in the Mini-MELF (Metal Electrode Leadless Face) outline (**Figure 4**). This package is a

1.4 mm diameter cylinder 3.6 mm long and is only used for diodes. It is one of the most tricky to manipulate with standard tweezers and tends to roll away during soldering. A variant on this outline casts the cylinder into a rectangular form to improve its handling properties so that the body of the chip in between the end caps is rectangular.

Transistors

Transistors are produced in the SOT 23 outline (**Figure 5**). This outline is a simple rectangular chip measuring 2.8 mm by 2.1 mm with three connections.

ICs

There is such a wide diversity of IC outlines that we can only look at a few of the more common package outlines. The μMAX series from Maxim is probably one of the most important from the point of view of the home constructor and includes the QFP, SOP and TSSOP outlines. A wide spectrum of IC functions is supplied ranging from A/D converters, logic gates and microcontrollers. When a PCB is designed the most important information for the layout is the thickness of the leads and the lead pitch or spacing for the ICs. All of the IC package outlines use a fixed pitch for spacing the leads. The main pitch spacing has always been 0.1 inch or 2.54 mm and IC Package outlines are multiples of this pitch spacing. To enable higher lead density this pitch has been progressively divided by two to give a spacing of 1.27 mm, 0.635 mm and more recently 0.3175 mm. Some manufacturers such as MAXIM use a non-standard pitch for example with their μMAX package outlines. The general rule is that the more densely spaced the leads are then the finer the soldering iron bit needs to be. At this stage we need to check that we have the basic tools necessary for SMD work.

SMD tools

There is much expensive SMD equipment and specialist tools available today but before you invest too much of your hard-earned cash it would be wise to try things out on a small scale. SMD work is not everybody's cup of tea and if you are not blessed with a steady hand things can get very frustrating.

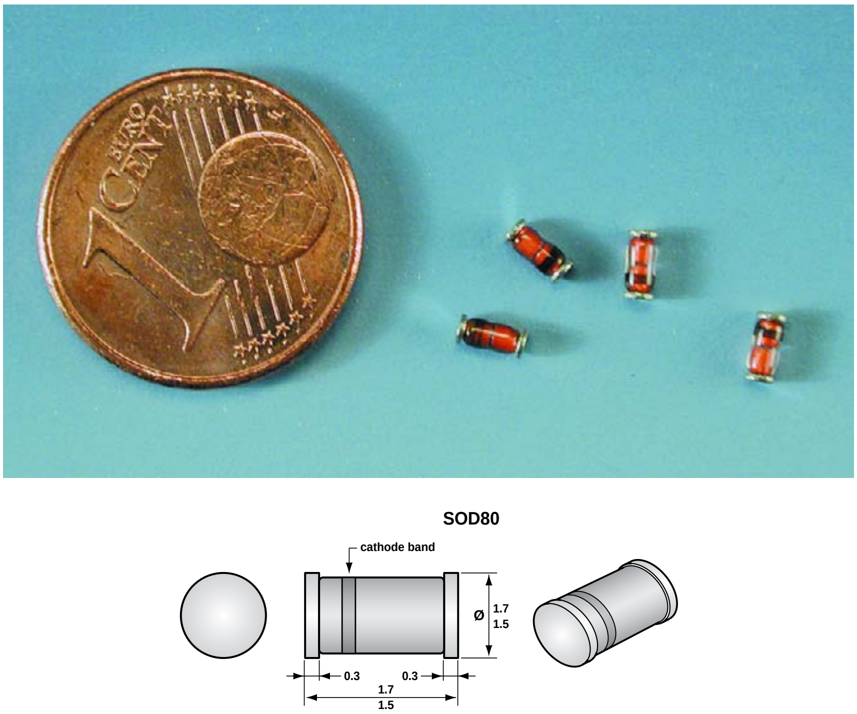

Figure 4. Mini-MELF diode outline.

The most important tool in your toolbox will be a pair of good quality tweezers. There are many different types to choose from and the most popular for SMD work (and certainly the author's preference) are tweezers featuring a 45° offset with smooth faced gripping points, these are convenient to use and enable you to steady your hand on the workbench as you pick and place the chip. It is important to buy good quality tweezers and the average price is quite high at around £8 to £10. Titanium or ceramic tweezers are also available but cost substantially more. Specially shaped tweezers suitable for picking up mini-MELF outline chips are also available but these can only be

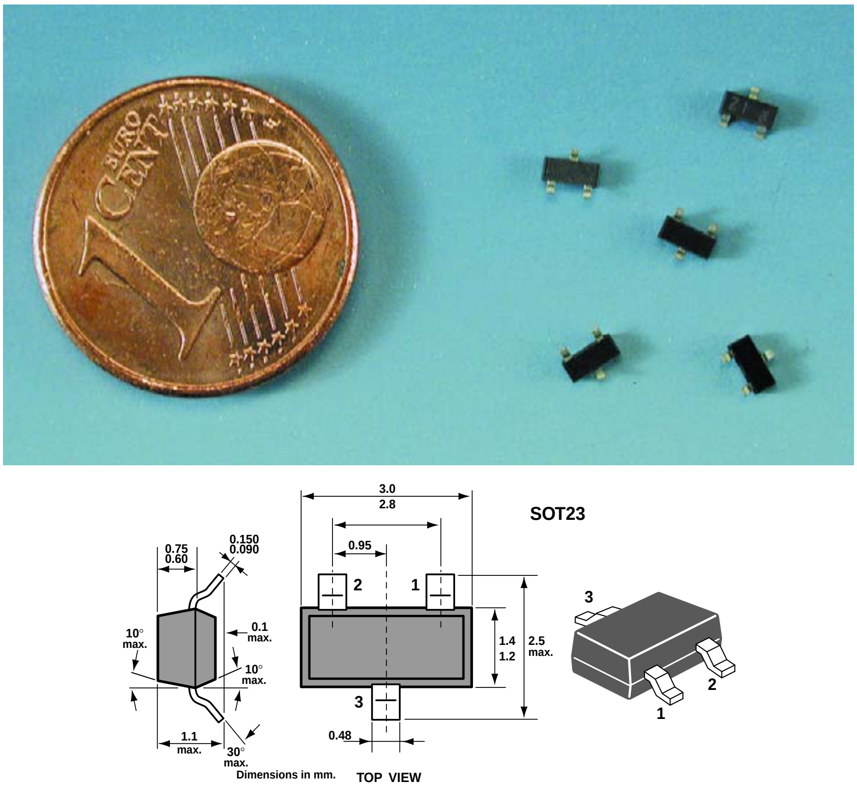

Figure 5. The SOT-23 transistor outline.

recommended if you are mounting lots of these components.

A vacuum pick-up pencil can also be used for component placement but this tool is relatively expensive and will not pick up a chip unless it has a flat smooth upper surface. These pencils are not really recommended for the beginner. An eyeglass with at least eight times magnification is also necessary. Avoid the desk mounted inspection magnifying lens with built-in fluorescent light, these are too awkward to use, best of all get a pair of head-mounted magnifying binoculars, these park on your head and can be easily flipped down when needed. A good level of background and directional lighting (halogen is best) is also important along with an anti-static mat and wristband to avoid damaging sensitive ICs.

The flux-cored solder used for SMDs has a very thin cross-section (26 SWG) and incorporates 2% silver; this lowers its melting point by a few degrees and also produces a better joint. Solder paste is also available in 5 ml syringes. Paste is easy to use but needs a steady hand for application and requires the residue to be cleaned off afterwards. Solder paste is intended for use with a hot-air type of soldering iron, these are expensive and not really necessary for the beginner. Solder paste can also be used with a conventional iron but its more economical to use standard cored SMD solder. When soldering ICs with a large number of connections close together it is necessary to use additional SMD flux paste. The flux should be dabbed onto the PCB pads from a syringe before the component is placed in position on the board. During soldering it burns off quickly leaving very little residue so it is usually unnecessary to clean the joints afterwards providing not too much flux has been used.

De-solder wick (or braid) is used to clean up the soldered joints and remove excess solder or unintentional solder bridges between pads. The most useful wick sizes for SMD work are 1.0 mm and 1.5 mm wide while 2.5 mm is useful for cleaning PCB pads. De-soldering pumps are not used because some of the components are so tiny they tend to disappear up the nozzle along with the molten solder.

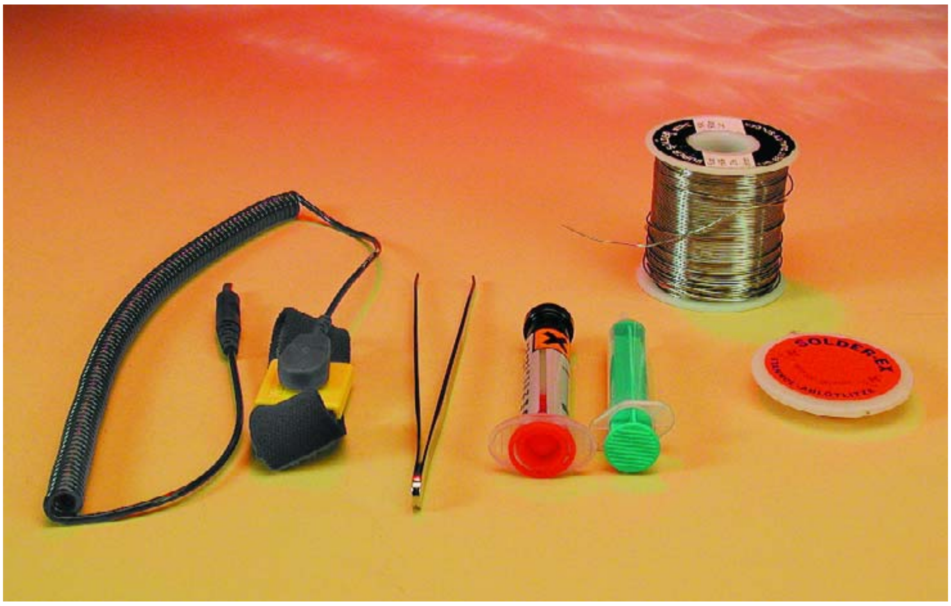

Figure 6.The basic SMD toolkit (from left: anti-static wristband, tweezers, flux, solder and de-soldering wick).

In the beginning when you do not have too many components it is not necessary to store the SMDs in boxes, just keep them in the original manufacturers packaging and only remove them when its time to solder them in place. As you gain experience and your SMD component collection increases then a set of chip containers with lids will help organise the workplace. You can purchase sets consisting of boxes of different size and colour or just buy individual boxes as you need them. It is a good idea to use separate containers for each component type and value. Component values are not always stamped on the SMD body so anyone who needs to sort through a pile of mixed capacitors looking for a particular value (sounds like a job for our capacitance meter Mini Project, see the December 2002 issue of *Elektor Electronics*) will soon be convinced of the benefits of a well ordered storage system. These chip containers are not cheap but they are worth the investment. Don't be tempted to store SMDs in plastic 35 mm film canisters, these are too deep for the purpose and are not treated with an anti-static coating so CMOS ICs can be damaged.

Coming soon…

In a follow-up article we will look at the techniques necessary for successful soldering of different types of SMD components using a standard soldering iron (the Ersa 'Analog 60A'). We also take a close look at a soldering station designed for SMD work (the Ersa SMT Unit 60A).

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Components, tools and equipment

All the major mail order component outlets supply devices in SMD outline and also stock the necessary tools and accessories for working with SMDs. Farnell (www.farnell.com) and RS (www.rs-components.com) both stock a huge variety of components and tools. Maplin (www.maplin.co.uk) are also a good source. BEC distribution (www.bec.co.uk) are distributors for TOKO coils and Electrovalue (www.electrovalue.com) stock SMDs and tools. A company worth trying for unusual components is Berend Hendriksen in the Netherlands (www.xs4all.nl/~barendh/indexeng.htm). Cooper Tools produce the excellent Weller range of soldering irons that can be obtained from the above suppliers.